BRAIN ACTIVATION CHANGES DURING POSITIVE AND NEUTRAL EMOTION REGULATION TASK FOLLOWING BRIEF MINDFULNESS EXERCISE: AN FMRI STUDY.

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by

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Table of Contents

ACKNOWLEDGEMENT ..... **ii**
LIST OF TABLES ..... **vi**
LIST OF FIGURES ..... **vii**
LIST OF ABBREVIATIONS ..... **viii**
ABSTRAK ..... **x**
ABSTRACT ..... **xii**
CHAPTER 1 INTRODUCTION **1**
1.0 Research Background 1
1.1 Problem Statement & Study Rationale 2
1.2 Research Question 5
1.3 Objectives of study 5
1.3.1 General Objective 5
1.3.2 Specific Objective 5
1.4 Hypothesis 6
1.5 Operational Definition 7
1.5.1 Mindfulness 7
1.5.2 Emotion regulation 7
1.5.3 Positive Emotion 7
1.5.4 Valence 7
1.5.5 Response Time 7
CHAPTER 2 LITERATURE REVIEW **8**
2.1 Mindfulness 8
2.2 Emotion regulation 9
2.3 Functional Magnetic Resonance Imaging 12
2.4 Functional Magnetic Resonance Imaging for Emotion Regulation 13
2.5 Response Time 16
2.6 Conceptual Framework 17
CHAPTER 3 METHODOLOGY **18**
3.1 Ethical Consideration 18
3.2 Research Design 18
3.3 Study area 19
3.4 Study population 19
3.5 Subject criteria 20
3.4.1 Inclusion criteria 20

3.4.2 Exclusion criteria 20
3.5 Sample size estimation 20
3.6 Sampling method and subject recruitment 22
3.7 Research Tool 22
3.7.1 Functional Magnetic Resonance Imaging (fMRI) 23
3.7.2 Positive and Neutral Emotion Task 23
3.7.3 Positive and Negative Affect Schedule Expanded Form (PANAS -X) 25
3.7.4 Mindfulness Attention Awareness Scale (MAAS) 26
3.7.5 Brief Mindfulness Exercise 27
3.7.6 Audiobook Listening 27
3.8 Procedure 28
3.9 Study flowchart 30
3.10 Data collection Method 31
3.10.1 Before fMRI recording 31
3.10.2 fMRI Data processing 32
3.10.2 (a) Slice timing 32
3.10.2 (b) Realignment 33
3.10.2 (c) Co-registration 33
3.10.2 (d) Segmentation 33
3.10.2 (e) Normalisation and Smoothing 34
3.10.2 (f) Subject–level analysis 34
3.10.2 (g) Fixed effect Analysis - Group Analysis 34
3.10.2 (h) Percent Signal Change 35
3.10.2 (i) Statistical Analysis 35
3.11 Data analysis 36
3.12 Milestone 36
CHAPTER 4 RESULTS 37
4.1 Introduction 37
4.2 Demographic Distribution of Respondents 37
4.3 Brain Activation 38
4.3.1 Audiobook Group for the Positive Emotion 38
4.3.2 Mindfulness Group for the Positive Emotion 41
4.3.3 Audiobook Group for Neutral Emotion 46
4.3.4 Mindfulness Group for the Neutral Emotion 49
4.4 Response Time of Positive and Neutral Emotion Task 54

4.4.1 Audiobook Response time 54
4.4.2 Mindfulness Group Response Time 55
4.5 PANAS – X 56
4.5.1. Audiobook Group 56
4.5.2 Mindfulness Group 57
4.6 MAAS Score 58
CHAPTER 5 DISCUSSION 59
5.0 Introduction 59
5.1 Positive and Neutral emotion-related brain activation 59
5.2 Response Time in Positive and Neutral Emotion 64
5.3 Positive Effect on Mindfulness and Audiobook Groups 66
CHAPTER 6 CONCLUSION 68
6.0 Conclusion 68
6.1 Limitation and Future Suggestions 69
Reference 70
APPENDIX
APPENDIX A: Ethical Approval
APPENDIX B: Social Media Advertisement
APPENDIX C: PANAS-X Questionnaire
APPENDIX D: MAAS Questionnaire
APPENDIX E: Randomization Sequence
APPENDIX F: Screening Questionnaire
APPENDIX G: Beck Depression Inventory
APPENDIX H: Budget
APPENDIX I: Paradigm Design

LIST OF TABLES

Table 1 Summary of sample size estimation for objective 21

Table 2 The estimated duration (minutes) to complete the procedure 29

Table 3 Data analysis of three objectives 36

Table 4 Milestone of study.....36

Table 5 Brain activated regions of the Positive Emotion task in pre- and post-task for Audiobook group. All activations were thresholded at $p_{uncorrected} < .001$ and extent threshold of 3 voxels.....40

Table 6 Brain activated regions of the positive emotion task in pre- and post-task for the mindfulness group. All activations were thresholded at $p_{uncorrected} < .001$ and extent threshold of 3 voxels.....44

Table 7 Brain activated regions of the neutral emotion task in pre and post-task for the audiobook group. All activations were thresholded at $p_{uncorrected} <0.001$ and extent threshold of 3 voxels.....48

Table 8 Brain activated regions of the neutral emotion task in pre and post-task for the mindfulness group. All activations were thresholded at $p_{uncorrected} < 0.001$ and extent threshold of 3 voxels.....52

Table 9 Wilcoxon signed-rank test for response time in the audiobook group 54

Table 10 Wilcoxon signed statics for response time in the audiobook group 54

Table 11 Wilcoxon signed-rank test for response time in the mindfulness group 55

Table 12 Wilcoxon signed statics for response time in the mindfulness group 55

Table 13 Wilcoxon signed rank test for PANAS -X score in the audiobook group.....56

Table 14 Wilcoxon Signed Statics Table for PANAS - X score in Audiobook group.....56

Table 15 Wilcoxon signed rank test for PANAS - X score in the mindfulness group 57

Table 16 Wilcoxon signed statics table for PANAS - X score in the mindfulness group 57

Table 17 Mann – Whitney U test ranks table in between the audiobook and mindfulness group for the MAAS questionnaire 58

Table 18 Mann-Whitney U test statistics table for the MAAS questionnaire 58

LIST OF FIGURES

Figure 1 Conceptual framework 17

Figure 2 Neutral words stimuli 24

Figure 3 Positive word stimuli 25

Figure 4 Study procedure flowchart 30

Figure 5 The conjunction activation maps of the positive emotion task in the audiobook group from FFX at $p_{uncorrected} < .001$ and extent threshold of 3 voxels. The colour bar represents the t-value. Different colourmap represents different time frame, whereby the hot colour represent pre-task and the blue colour represent post-task. 39

Figure 6 The conjunction activation maps of the positive emotion task in the mindfulness group from FFX at $p_{uncorrected} < .001$ and extent threshold of 3 voxels. The colour bar represents the t-value. Different colourmap represents different time frame, whereby the hot colour represent pre-task and the blue colour represent post-task. 43

Figure 7 The conjunction activation maps of the neutral emotion task in the mindfulness group from FFX at $p_{uncorrected} < 0.001$ and extent threshold of 3 voxels. The colour bar represents the t-value. Different colourmap represents different time frame, whereby the hot colour represent pre-task and the blue colour represent post-task. 51

LIST OF ABBREVIATIONS

fMRI – Functional Magnetic Resonance Imaging

EEG – Electroencephalography

ANEW – Affective Norms for English Words

PANAS – X – Positive Affect and Negative Affect Scale Expanded Form

MAAS – Mindful Attention Awareness Scale

DLPFC – Dorsolateral Prefrontal cortex

ACC – Anterior Cingulate Cortex

MRI – Magnetic Resonance Imaging

OFC – Orbitofrontal cortex

BOLD – Blood Oxygen Level Dependent

STC – Slice timing Correction

EPI – Echo Planner Imaging

ROI – Region of Interest

LING – Lingual gyrus

MOG – Middle occipital gyrus

ITG – Inferior temporal gyrus

MC – Mid cingulum

PoCG – Postcentral gyrus

CAL – Calcarine cortex

IOG – Inferior occipital gyrus

SOG – Superior occipital gyrus

PCG – Posterior cingulate gyrus

SPG – Superior Parietal gyrus

PreCG – Precentral gyrus

TriIF – Triangularis Inferior frontal

MFG – Middle frontal gyrus

PCu – Precuneus

SMA – Supplementary motor area

IFoper – Inferior frontal operculum

SFG – Superior frontal gyrus

OperR – Operculumm Rolandic

SPSS – Statistical Package for the Social Sciences

RT – Response Time

Perubahan Aktiviti Otak Ketika Tugasan Pengawalan Emosi Positif dan Neutral Selepas Latihan Keprihatinan Ringkas: Satu Kajian fMRI

ABSTRAK

Pengenalan: Keprihatinan berpotensi untuk membawa kesedaran dan tumpuan seseorang kepada keadaan dan pemikiran semasa. Ia juga meningkatkan emosi positif di mana orang yang berada dalam keadaan berkeprihatinan ini berupaya mengawal emosi mereka dan mengurangkan emosi negatif. **Objektif:** Kajian ini bertujuan mengenal pasti aktiviti otak yang berkaitan dengan tugasan pengawalan emosi positif dan neutral selepas latihan keprihatinan ringkas dijalankan. **Metodologi:** Kajian ini mensasarkan golongan dewasa yang sihat dan muda sebagai peserta. Keadaan keprihatinan peserta dinilai menggunakan Skala Keprihatinan Tumpuan dan Kesedaran (MAAS) dan keadaan emosi terhadap tugas pengawalan emosi dinilai menggunakan Skala Perasaan Positif dan Negatif – Diperluas (PANAS-X). Alat neuroteknologi digunakan iaitu pengimejan resonans magnetik kefungsian (fMRI) untuk mengenal pasti aktiviti dan pengaktifan otak bagi emosi positif dan neutral. Tugasan pengawalan emosi positif dan neutral yang diukur sebelum dan selepas latihan keprihatinan ringkas terdiri daripada perkataan-perkataan rangsangan bersifat positif dan neutral yang diekstrak daripada *Affective Norms for English Words* (ANEW). **Hasil kajian**: Enam orang peserta telah terlibat dalam kajian ini dan mereka dibahagikan kepada dua kumpulan: kumpulan pertama mendengar audio keprihatinan dan kedua adalah kumpulan kawalan mendengar audio buku. Peserta dalam kumpulan keprihatinan menunjukkan pengaktifan dalam operkulum hadapan inferior, tri-inferior

frontal, frontal superior dan calcarine semasa tugasan pengawalan emosi positif, dan menunjukkan pengaktifan dalam operculum Rolandic, gyri postcentral, calcarine dan gyri precentral semasa tugasan pengawalan emosi neutral. Masa tindak balas bagi kedua-dua kumpulan keprihatinan dan kawalan adalah tidak signifikan ($p > 0.05$) tetapi keduanya menunjukkan kesan bersaiz besar selepas tugasan. Keadaan emosi positif bagi kedua-dua kumpulan adalah tidak signifikan ($p > 0.05$). Dua peserta dari kumpulan audio buku menunjukkan kesan saiz sederhana terhadap emosi positif manakala peserta dari kumpulan keprihatinan menunjukkan kesan saiz besar terhadap emosi positif, seperti yang diukur melalui PANAS-X. **Kesimpulan**: Visual, motor dan bahasa mempunyai pengaktifan yang lebih tinggi dan keadaan ini dirumuskan kerana kehadiran audio buku, audio keprihatinan, dan perkataan bersifat merangsang pengawalan emosi. Kumpulan audio keprihatinan menunjukkan sedikit pengawalan emosi positif. Saiz sampel yang kecil mengurangkan ketepatan keputusan kajian ini, tetapi kesan saiz yang besar menunjukkan bahawa perbezaan dalam masa tindak balas dan kesan emosi? positif berbaloi untuk dijalankan dalam kajian akan datang. Kajian ini dicadangkan untuk diperluaskan kepada semua peringkat umur. Dalam kajian awal ini, latihan keprihatinan ringkas dengan jangka masa 15 minit dapat mengenal pasti kesan emosi terhadap seseorang individu.

Kata Kunci: Keprihatinan, Emosi positif. fMRI, ANEW, Dewasa muda

Brain activation changes during positive and neutral emotion regulation task following brief mindfulness exercise: An fMRI study

ABSTRACT

Introduction: Mindfulness is used to bring awareness and focus to a present state of mind. It also enhances positive emotion where people with a mindfulness state have control of their emotion and reduces the regulation of negative emotion. **Objective:** This study focuses to identify the associated brain activation of positive and neutral emotion regulation task following brief mindfulness exercises. **Methodology:** This study focuses on the healthy and young adult population. A neurotechnology tool is used which is functional magnetic resonance imaging (fMRI) to identify the brain activation of positive and neutral emotions. The positive and neutral emotion regulation task which was measured during the pre and post task consisted of positive word and neutral word stimuli which are extracted from Affective Norms for English Words (ANEW). Mindfulness state is assessed using the Mindful Attention Awareness Scale (MAAS) and the affect of the positive emotion regulation task is assessed using the Positive Affect and Negative Affect Scale – Expanded (PANAS-X). **Results:** Six participants were included in this study. The mindfulness group for positive emotion showed activation in the inferior frontal operculum, tri – inferior frontal, superior frontal and calcarine, while the neutral emotion showed activation in Rolandic operculum, postcentral gyri, calcarine and precentral gyri. The response time for both groups was insignificant ($p > 0.05$) but displayed a large size effect over the post-task. The positive effect for both groups was insignificant ($p >$

0.05) but the audiobook group, showed a medium size effect while the mindfulness group showed a large size effect in the positive affect of PANAS – X. **Conclusion:** Visual, motor, and language had higher activation which would be defined by the presence of the audiobook and mindfulness audio and word stimuli while the mindfulness audio group showed a slight regulation of positive emotion. The small sample size showed the reduced efficiency of the results, but the large effect size indicated that differences in response time and positive effects are worth to be conducted in future studies. The study is suggested to be expanded to all age groups. In this preliminary study, a brief mindfulness exercise with 15 minutes time frame was able to identify the emotional effect on an individual.

Keywords: Mindfulness, Positive emotion. fMRI, ANEW, Young adults

CHAPTER 1 INTRODUCTION

1.0 Research Background

From birth to young adulthood, an individual's highly cognitive processes develop before deteriorating as they get older (Janz et al., 2019). According to biological and behavioural theories, women's social and biological roles in giving birth and raising children may play a r ole in the formation and organisation of brain structures linked to emotion (Reber and Tranel, 2017). A wide range of biological and social factors affect the brain's role and physical growth over time. Emotions are involved in situations that have a wide variety of rewarding or traumatic experiences. Poor emotion regulation has been linked to mood and anxiety disorders, poor mental health, and decreased well-being (Picó-Pérez et al., 2017; Rodas et al., 2021). Keeping these feelings in check is always a choice and a deliberate act done to keep life going.

Cognitive control is the ability to align one's mind and actions with task-related priorities. It is made up of several different executive functions, including attention shifting, error detection, working memory preservation and upgrading, and the response to conflict or inhibition (Banich et al., 2009; Song et al., 2017). Fundamental abilities are closely linked to children's social and emotional well-being, which is usually measured using emotional regulation (Maynard et al., 2017). Conflict in the context of cognitive control takes place when emotional interference occurs during a task. Hence, The ability to assign an emotional or mental state to another person which is cognitive empathy necessitates a number of cognitive control mechanisms that help coordinate oneself and other perspectives (Derek et al., 2007; Thompson et al., 2022). In spite of the fact that emotion and cognitive regulation are separate brain processes, research has

indicated a similar neural circuitry underpinning cognitive-emotional dispute resolution (Lindquist et al., 2012; Shackman et al., 2011). Each of the distinct feelings, such as pleasure, sorrow, rage, and terror, is thought to be served by the neural system (Lindquist et al., 2012; Posner et al., 2009).

Mindfulness is a form of consciousness that makes use of two other essential aspects of consciousness: perception and focus (Lothert, 2022; Valim et al., 2019). When it comes to emotion regulation, mindfulness meditation is the most researched, and meditative activities have also been linked to positive emotions. Mindfulness can boost individuals' ability to attend to specific aspects of a situation as well as aspects of their own experience by fostering enhanced and expanded focus and perception in the present moment thereby improving their detection of the need to apply regulation strategies (Roemer et al., 2015).

1.1 Problem Statement & Study Rationale

A study showed that it was difficult to distinguish between the neural activity required to produce valence and arousal scores for emotional stimulus assessment and the neural activity required to directly generate the resulting emotional experience (Posner et al., 2009). Furthermore, no research on the relationship between positive and neutral word triggers, which help in emotion control, has been conducted in Malaysia to date. Given the shortcomings of self-reporting, studies should look at a range of emotion regulation strategies incorporating both behavioural and physiological measures (Orgeta, 2009).

Combining positive and negative word stimuli can cause muddied emotional responses, limiting post-hoc individual analysis (Malhi et al., 2005). Researchers stated that there was no behavioural evidence in their research where the interpretation of the brain imaging data was limited (Rahm et al., 2013). It was

discovered that older adults use more emotion regulation control than younger adults (Wierenga et al., 2016). Mindfulness meditation helps regulate emotion in which it suppresses negative emotion and increases positive emotion that leads to a positive state of being (E. Garland et al., 2009). We were unable to assess whether particular drug combinations are more or less effective since the majority of patients were on psychiatric drugs (Painter et al., 2019). A study suggested future research should look into the timing of these techniques and see whether mindfulness or consciousness occurs before these results, as well as provide more comprehensive monitoring factors like relaxing to assess the specificity of mindfulness's impact (Roemer et al., 2015). Many research has shown that negative stimuli produce a large emotional Stroop effect. It is thought that negative stimuli induce a strong emotional Stroop effect, regardless of whether the stimuli are emotional words, emotional visuals, or other forms of stimuli, since negative stimuli offer crucial danger or alert information (Quan et al., 2020). In general, a lack of response to positive stimuli appears to have inconsistent results.

In most studies the outcomes are limited to mindfulness mediation protocols, narrowing the application of the findings to this specific activity (Khoury et al., 2013). It also stated that mindfulness-based therapy became more attentive at the close of the treatment, and their gains were sustained at the final check-up. According to PET research, was consistently more involved during cognitive activities but less active during emotional tasks, namely the dorsolateral prefrontal cortex (DLPFC) and the dorsal anterior cingulate cortex (ACC) (Compton et al., 2003). Limited research targets positive emotion regulation in adults and gives more importance to negative emotion regulation (Young et al., 2019). Mindfulness can be used to treat a wide range of psychiatric conditions, as well as to relieve

tension from everyday life and encourage positive self-acceptance (Jennings and Jennings, 2013). Previous studies have stated the limitation of the small size of the training group and participants were adolescents in regards to mindfulness exercise (Jennings and Jennings, 2013).

This study is crucial to be conducted to identify the neural activity in valence emotional stimuli. It is necessary to overcome the shortcoming of self-reporting by incorporating emotional psychological measures in this study. This study is determined to focus on one emotional regulation which does not affect the individual responses. Researcher has chosen to exclude subjects who are under psychiatric drugs which would influence the brain association. This study will focus on participants from the young adult age group and used a randomised trial to expand the validity of this population. This study tends to increase the validity and explore the brain activation of positive emotion task by implementing brief mindfulness exercises in the young adult age group. Furthermore, the implementation of brief mindfulness would widen the scope of understanding the effect and impact of mindfulness. Moreover, response time study focuses more on negative stimuli response as compared to positive stimuli. Lastly, this study would use focus into using neuroimaging functional magnetic resonance imaging (fMRI) modality to widen the results in mindfulness and positive emotion regulation.

1.2 Research Question

1. Are there any brain activation in positive and neutral emotion task before and after the brief mindfulness exercise and brief audiobook using fMRI?
2. Are there any changes in comparing the changes in response time in positive and neutral emotion task before and after brief audio mindfulness exercise and brief audiobook?
3. Are there any changes in young adult's emotion levels based on the Positive and Negative Affect Schedule Expanded Form (PANAS – X) score before and after the brief mindfulness exercise and brief audiobook?

1.3 Objectives of study

1.3.1 General Objective

To identify the changes in positive and neutral emotion regulation task and the associated brain activation following a brief audio mindfulness exercise and brief audiobook exercise.

1.3.2 Specific Objective

1. To determine the brain activation in the positive and neutral emotion task before and after brief mindfulness exercise and brief audiobook using fMRI.
2. To compare the changes in response time in the positive and neutral emotion task before and after brief audio mindfulness exercise and brief audiobook.
3. To determine changes in young adult's emotion levels based on PANAS – X score before and after a brief mindfulness exercise and brief audiobook.

1.4 Hypothesis

1. **H_0**: There will be no significant brain activation in the positive and neutral emotion task before and after a brief mindfulness exercise and brief audiobook using fMRI

   H_1: There will be significant brain activation in the positive and neutral emotion task before and after a brief mindfulness exercise and brief audiobook using fMRI

2. **H_0**: There will be no significant changes in response time in the positive and neutral emotion task before and after the brief audio mindfulness exercise and brief audiobook

   H_1: There will be significant changes in response time in the positive and neutral emotion task before and after a brief audio mindfulness exercise and brief audiobook

3. **H_0**: There will be no significant changes in young adult's emotion levels based on PANAS - X score before and after a brief mindfulness exercise and brief audiobook

   H_1: There will be significant changes in young adult's emotion level based on PANAS – X score before and after brief mindfulness exercise and brief audiobook.

1.5 Operational Definition

1.5.1 Mindfulness

In this context, mindfulness is described as "paying attention, on intent, in the present moment, nonjudgmentally (Roemer et al., 2015).

1.5.2 Emotion regulation

Emotion regulation defines as where an individual can control the feelings they have when they have them, and how they feel and communicate them to others (Roemer et al., 2015).

1.5.3 Positive Emotion

Positive emotions are indicators of flourishing, or optimum well-being, and are instances in people's lives marked by like pleasure, interest, contentment, and passion (Fredrickson, 2001).

1.5.4 Valence

The pleasantness or unpleasantness of an emotional stimulus is referred to as valence (Kauschke et al., 2019).

1.5.5 Response Time

The amount of time it takes an individual in a test of task to react to individual questions (De Boeck and Jeon, 2019).

CHAPTER 2 LITERATURE REVIEW

2.1 Mindfulness

Mindfulness meditation has been shown to have positive effects on mental and physical states as a therapeutic technique, especially in terms of cognitive development and rehabilitation from affect-related psychopathology (Wielgosz et al., 2019). Training in mindfulness therapy for four days (20 min daily) (Wu et al., 2019). Adult mindfulness training activities will take up to 26 hours and eight 2.5-hour lessons over eight weeks, but this study only used four 50-minute courses in three weeks (Jennings and Jennings, 2013). Improved cognitive processes such as visuospatial processing, working memory, and executive functioning, as well as reduced depressive emotions like nausea and anxiety. Individuals become less prone to negative internal phenomena and more reflective when performing mindfulness (e.g., by sitting meditation, yoga, or other mindfulness exercises), which leads to beneficial therapeutic results (Hofmann and Gómez, 2017). Mindfulness is a mental state marked by non-judgmental knowledge of one's sensations, emotions, bodily states, memory, and atmosphere while promoting tolerance, interest, and acceptance (Guendelman et al., 2017). There are two elements of mindfulness: one that includes 1) concentration self-regulation and 2) the other that involves a curiosity, tolerance, and acceptance orientation toward the present moment (Hofmann and Gómez, 2017).

Mindfulness-Based Interventions are based on the idea that through performing mindfulness (e.g., by sitting meditation, yoga, or other mindfulness exercises), people become less prone to negative internal phenomena and more reflective, which contributes to better therapeutic results (Hofmann and Gómez, 2017).

Intervention exercises such as daily positive, mindfulness and goal setting can help focus on strategies of associated brain activation of positive emotion regulation (de Siqueira Rotenberg et al., 2020). Mindfulness and emotion regulation have merged in reducing aggression and channelling it towards an adaptive purpose (Garofalo et al., 2020). When it comes to emotion regulation, mindfulness (MF) meditation is the most researched, and meditative activities have also been linked to positive emotion (Valim et al., 2019). Mindfulness is the method of guiding consciousness to a present moment with the aid of the control of sustained attention in this subject (E. Garland et al., 2009). Mindfulness-Based Stress Reduction has displayed beneficial influences on clinical populations issues and also affected the population in a positive effect manner (Chiesa et al., 2011).

A 10-minute mindfulness intervention or a 15-minute guided breathing meditation will reduce the intensity and negativity of emotional reactions to affectively valenced external stimuli almost instantly (Wu et al., 2019). Even brief compassion meditation training (6 hours) increases positive affect and amplifies positive feelings toward others, followed by higher activity in the ventral striatum and medial orbitofrontal cortex (Klimecki et al., 2013; Förster and Kanske, 2022).

2.2 Emotion regulation

Emotions act as strong prisms from which people perceive social knowledge and their surroundings (Qiao-Tasserit et al., 2017). The ‘process by which individuals control the feelings they have, where they have them, and how they feel and communicate them, with a focus on regulation rather than eliminating of emotional responses and adaptive behavioural responses to the world,' is defined as emotional regulation (Roemer et al., 2015). The perception of current generated

emotions, which are formed from emotional events. Under specific conditions, both positive and negative emotions have adaptive roles (Du et al., 2019)**.** The facilitation of adaptive emotion regulation has been suggested as one mechanism for the reported therapeutic consequences of mindfulness (Khoury et al., 2013).

Emotions are a mix of valence and arousal, two underlying, relatively separate neurophysiological processes (Posner et al., 2009). The valence system decides whether an emotion is positive or negative, while the arousal system determines how behaviourally stimulating it is (Compton et al., 2003). The arousal component decides the intensity of the approach/avoidance behaviour, while the valence component encourages a person to reinforce an approach/avoidance behaviour (Gu et al., 2019). Valence characteristics differ from extremely pleasurable feelings like happiness or excitement to extremely painful ones like anguish or despair. Arousal levels can range from coma or sleep to extreme excitement or hysteria on the other end of the spectrum (Kandel et al., 2000). For example, of term excitement word stimulus is a high-arousal, positively valence feeling experienced in anticipation of or during a future event. Contentment is a low-arousal word stimulus, a positive valence feeling that expresses satisfaction in the present based on recent events (Goldin et al., 2014).

Simple emotion theory, which argued that all human emotions are comprised of a small number of basic emotions (e.g., fear, frustration, excitement, sadness), which are perceived to be more elementary than others, has been very influential in the field of affective research in recent decades. Basic feelings are referred to as such since they are biologically and psychologically "basic" (Wang et al., 2017). Human beings are the only ones who can actively recognise their emotions, and

they are the only ones who can consciously regulate their emotions (Gu et al., 2019).

Positive emotions have been claimed to be more prevalent in people's daily lives than negative emotions. Although there is a heavy focus on suppressing negative emotions in everyday life, it appears that upregulating, maintaining, and savouring positive emotions is equally advantageous to our well-being (Förster and Kanske, 2022; Quoidbach et al., 2010). According to the *broaden-and-build theory of positive emotions,* positive emotions can aid in the development of long-term resources, the expansion of one's way of thinking and doing, and the acquisition of more flexible higher-level connections as well as a wider range of precepts', ideas, and behavioural abilities (Barbara, 2008; Du et al., 2019). The prefrontal cortex focuses on the dorsomedial prefrontal cortex, dmPFC where is hypothesised to impact other frontal and limbic areas of emotion regulation processing, such as the ventromedial prefrontal cortex (vmPFC) and the amygdala which are tightly linked (Koush et al., 2019).

In experimental studies of affect, mood, and emotion, neutral affect are crucial because they frequently serve as a control condition (Gasper, 2018). In a study, it states that older adults displayed a bigger decrease in negative emotion than younger adults, while being less effective at focusing their attention on neutral stimuli content (Wirth and Kunzmann, 2018). Being mindful may help us become more conscious of our thoughts, bodies, and emotions. It strengthens our sense of security in the moment and enables us to see our thoughts and feelings neutrally without being affected by strong emotions. Previous study findings stated there were no emotion regulation pattern in amgydala and vmPFC during the display of neutral images (Doré et al., 2019). There have also been suggestions that children

and adults have varied amygdala development, with children responding less specifically in the amygdala to various emotional expressions than they do to neutral faces (Belden et al., 2014). Studies with phobic group participants showed strong decrease in right Dorsal Medial Prefrontal Cortex (dmPFC) when compared with neutral pictures. Several brain areas, including the insula, the middle temporal gyrus, and the caudate nucleus, showed an overall reduction in activity for phobic compared with neutral stimuli. It has been demonstrated in the past that certain of these areas become activated when specific phobia symptoms are provoked (Hermann et al., 2013).

2.3 Functional Magnetic Resonance Imaging

Neuroimaging tools is a collection of techniques that look at brain neural associations in order to link changes in activity to specific task, behaviour and experiment (Whitten, 2012). fMRI is based on magnetic resonance imaging (MRI), which uses nuclear magnetic resonance in conjunction with magnetic field gradients to produce images with high spatial resolution and non-invasiveness that can include a variety of contrasts such as T1 weighted images, T2 weighted images, susceptibility and flow (Hatchard et al., 2021).

Higher localised brain activity leads to increased metabolic rate and blood flow, according to all fMRI metrics (Glover, 2011). The findings of indirect brain function assessment are sometimes displayed as a statistical map that depicts regional activity (Soares et al., 2016). The metabolically complex process of information transmission between neurons needs a larger flow of oxygenated blood which is known as oxyhaemoglobin. Hence, Because of the local inflow of oxygenated blood, the ratio of oxygenated arterial blood to deoxygenated venous

blood increases, resulting in a net increase in the balance of oxygenated arterial blood to deoxygenated venous blood, which is linked with higher deoxyhaemoglobin (Buxton, 2013). Radioactive substances are not required where it has chances of impacting the activation of neural area (Zafar et al., 2016a).

For fMRI research, there are two main types of experimental designs are blocked and event-related designs. To sustain cognitive engagement, a condition is given continuously for a prolonged time span (block), and several task conditions are frequently alternated in time (Petersen and Dubis, 2012; Tie et al., 2009). Robustness, a relatively substantial blood-oxygen-level-dependent (BOLD) signal shift compared to baseline and higher statistical power are all advantages of blocked design (Tie et al., 2009). Separating the pieces of an experiment into separate points in time, known as "event-related fMRI," allows the cognitive processes (and corresponding brain responses) connected with each element to be studied individually (Huettel, 2012). An event-related design's inter-stimulus-interval (ISI) is a critical parameter. An ISI that is longer than the duration of the hemodynamic response function (HRF, 10–12 s) is referred to as a slow event-related design (Buckner et al., 1996), whereas an ISI that is less than the duration of the HRF is referred to as a rapid event-related design (Mitchell et al., 2002)

2.4 Functional Magnetic Resonance Imaging for Emotion Regulation

In comparison to activities during supposedly emotion-neutral interactions, functional imaging experiments have shown neuronal activity during the experience of real emotions (Posner et al., 2009). Many prior neuroimaging experiments sought to classify distinct and dissociable pathways that serve one of several basic feelings, such as the amygdala, which supports fear (LeDoux, 2003; Lutz et al., 2017). Some electroencephalography (EEG) experiments have

identified the temporal unfolding of brain responses to emotional events (pictures) and shown that different emotions have distinct characteristics at the subsequent timescale. (Qiao-Tasserit et al., 2017). Recent fMRI study has identified some particular loci in the brain that function for basic emotions, and these neuroimaging researchers have confirmed some specific loci in the brain that work for basic emotions (Gu et al., 2019). Sadness emotion is connected to the anterior cingulate cortex (ACC). The previous study has used knowledge of mindfulness and its clinical implications for disrupted positive emotion regulation in disorders like manic episodes and depressed anhedonia (Lutz et al., 2013). A combination of implicit and explicit mechanisms may be involved in mindfulness-based emotion regulation. According to studies, there is an increase in positive emotion and a decrease in negative emotion (Hölzel et al., 2011; Lutz et al., 2017; Tang et al., 2016).

Even though neuroimaging studies have shown some support for basic emotions such as the amygdala for anxiety, insula for disgust anterior cingulate cortex for depression, and orbitofrontal cortex for indignation these findings are not compatible with a clear one-to-one correspondence between fMRI localization and emotion (Gu et al., 2019). An fMRI research to was used to consciously control their negative emotions in response to images of marginalised people and other non-stigmatized negative social goals in order to compare the neural activity engaged during the task (Krendl et al., 2012). The previous study has primarily focused on the down-regulation of negative emotions and established brain regions that promote this regulation: Typically, prefrontal and parietal cortical “cognitive control” regions have been found to modulate subcortical regions implicated in emotional responses (Grosse Rueschkamp et al., 2020). While the degree of

amygdala regulation was negatively associated with depressive severity, one functional magnetic resonance imaging fMRI study showed that medicated depressed adults could cognitively decrease amygdala activation elicited by negative images (Dillon and Pizzagalli, 2013). In a negative emotional state, the frontal lobe of the brain is not involved, and brain areas are less associated, preventing the brain from remembering and associating sounds, and only recalling any of the words used during the learning stage (Li et al., 2021). Previous research on emotion regulation presents activation of the posterior cingulate cortex, anterior cingulate cortex and prefrontal cortex and also significant changes in the amygdala (Hölzel et al., 2011; Huang et al., 2019).

In the medial and middle prefrontal cortex, medial orbitofrontal cortex, and occipital gyrus, the positive emotion resulted in considerably elevated BOLD responses (Wang et al., 2017). For positive emotion, researchers discovered activity in the medial orbitofrontal cortex (OFC), which was similar to previous findings using International Affective Picture System (IAPS) photos (Kensinger and Schacter, 2006; Vink et al., 2014; Y. Wang et al., 2017), showing that this region was engaged in processing pleasant or rewarding stimuli. The Ventral Striatum is shown to link to both reward-related behaviour and positive emotional responses in general, such as pleasant music, smiling faces, or positive pictures (Grosse Rueschkamp et al., 2020). The support is strong that the activation of the ventral striatum is high during positive stimuli as compared to neutral stimuli.

Previous studies tend to focus more on negative emotion regulation as compared to positive emotion regulations. Based on study evidence, emotional responses are closely linked to the prefrontal cortex and orbitofrontal cortex which is regardless of the distinct emotion. The task used to regulate positive emotions

are the Emotional Stroop task, International Affective Picture System (IAPS), music, smiling faces and positive images which shows minimal activation of areas related to positive emotion. There is a lesser study which uses mindfulness to study positive emotion as compared to negative emotion.

2.5 Response Time

A study results has revealed that the RTs for neutral words were longer than those for highly emotional terms, demonstrating that the emotional Stroop effect has a strong slow component that delays the reaction to subsequent stimuli, indicating a delay in disengaging attention (Liu et al., 2018). The emotional Stroop task was also used to examine the word recognition of language 1 and language 2-word processing. They utilised solely negative and neutral words to focus on the emotional Stroop effect. When negative and taboo words were offered, they detected interference in both languages, slowing Response Time (RT) relative to neutral ones. This impact was not seen in neutral or positive terms (Roberts, 2021). According to evolutionary theory, the neural system ("negative brain") has evolved to ensure swift and strong reactions to negative stimuli (Carretié et al., 2009). Negative stimuli necessitate a greater and more immediate activation of processing and reaction resources. This sense of urgency would have clear adaptive and evolutionary benefits. In general, a lack of responsiveness to positive stimuli appears to have less serious results (Quan et al., 2020).

2.6 Conceptual Framework

Based on the literature review, the conceptual framework of this study is illustrated in Figure 1.

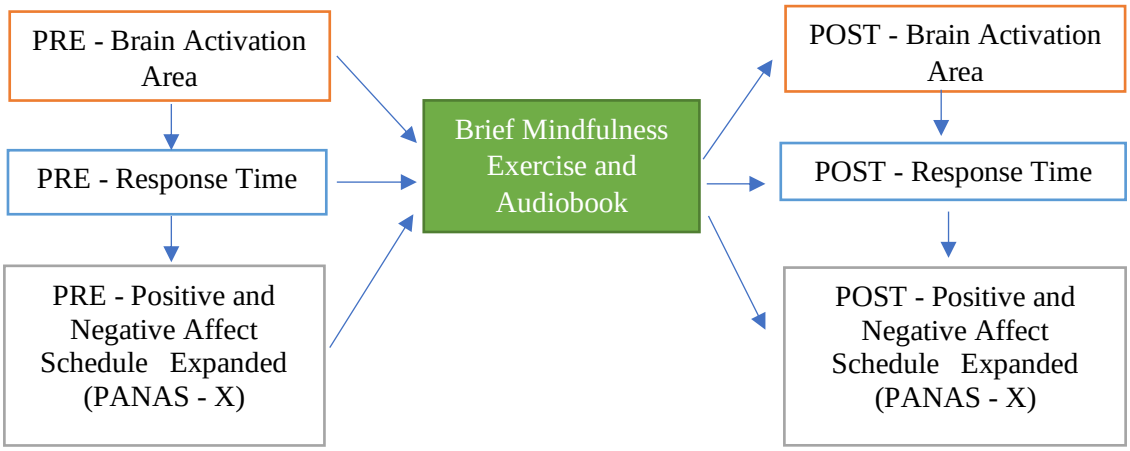

Figure 1 Conceptual framework

The conceptual framework is to describe what the study hopes to identify in the study. It shows the related dependent and independent variable and the relationship between them. This research uses the brief mindfulness exercise and audiobook as an independent variable to study the brain activation area, the response time and positive effect which are the dependent variable.

CHAPTER 3 METHODOLOGY

3.1 Ethical Consideration

The study procedures were approved by the ethics committees (USM/JEPeM/21060422) of Universiti Sains Malaysia (USM). The ethics letter and radiology department approval were obtained from USM as this study used the fMRI facility. The ethics committee approval was obtained on 7th November 2021 (refer to Appendix 7) and the radiology department's approval was obtained on 10th November 2021(refer to Appendix 8). As for the participants, informed consent forms were given to be filled out before data collection which contained the subjects' rights and protection of their data. Their privacy and confidentiality of information in this study were assured to be kept safe where their identification will not be reported and subjects were allowed to withdraw from this study anytime. The data collected was stored in a hard disk where it will be safely kept with password encrypted hard disk. The laptop device used to access was protected with a password and kept in a safe place where it cannot be accessed by another team person. There were no conflict of interest with any organization, company or department in relation to this study. The funding for this study was obtained from the USM Bench fees of postgraduate studies and there were no conflict of interest with the Neuroscience department. The funder has no role in the study design, data collection and analysis or preparation.

3.2 Research Design

The study was conducted by a pseudo randomization study design where the data collection was obtained over. This study had two groups of subjects the audiobook group and the mindfulness exercise group to determine the associated brain activation in positive emotion regulation tasks. This design was chosen because

the groups contained an almost equal number of participants with equal male and female participants in the two groups which were the mindfulness audiobook group and the mindfulness exercise group.

3.3 Study area

The study was conducted at Universiti Sains Malaysia (USM) Kubang Kerian where subjects were recruited. Young adults who were eligible in the category and were willing to participate in this study registered by advertisement through social media (refer to Appendix 1). Subjects were briefed on the study before it was conducted. Data collection was conducted in MRI Suite, Department of Radiology, Hospital Universiti Sains Malaysia (Hospital USM).

3.4 Study population

The population of the study were young adults residing in Kelantan who were healthy young adults aged 19-34 years old (Franssen et al., 2020). "Heathy" young adults were referred as subjects who self-declared themselves as healthy in verbal terms without medical screening. The subject was selected based on no previous neuropsychiatric health issues history or under psychiatric medication where subjects self-declared themselves and questionnaire screening. The screening questionnaire was adapted from various sources which are inclusive of demographics of participants and simple neuropsychiatric assessment questions (Refer to Appendix 4). The screening includes Beck Depression Inventory to assess the participant's depression level. MAAS questionnaire was used to assess the subject's mindfulness level before the task as a screening tool.

3.5 Subject criteria

3.4.1 Inclusion criteria

Subjects were chosen among young adults who registered for this study through social media advertisements. The subjects were required to fulfil the inclusion criteria stated below:

a. Malaysian citizen
b. Healthy young adults aged 19-34
c. No neuropsychiatric health issues history or under psychiatric medication where subjects self-declare themselves and questionnaire screening.
d. Able to speak, read and understand English or Bahasa Malaysia

3.4.2 Exclusion criteria

Below are the exclusion criteria that subjects were required to fulfil in order to participate in this study:

a. Participants with metal implants
b. Claustrophobia
c. Prior experience with meditation or brief mindfulness exercise
d. Pregnant women

3.5 Sample size estimation

G*Power Software was used to measure the sample size requirements. The sample size was estimated using these three options since the planned statistical study (Repeated measurements ANOVA) examines between factor effect, within factor effect, and within-between interaction effect. The estimated sample size was calculated using parameters from previous fMRI research (Desmond and Glover,

2002). The effect size of f = 0.4 which is interpreted as large effect was proposed by Cohen (1988) to estimate the sample size of two group. The large effect size value was used to obtain large sample size to produce a significant result. The sample size was estimated to be a total of 44 subjects including a 10% of dropout rate due to withdrawal or technical errors during experiments, where 22 subjects will be in mindfulness audiobook and mindfulness exercise groups respectively without any bias (see Table 1). Due to Budget availability, a total of 8 participants were recruited where 2 subjects were used for the pilot study and 6 were involved in the actual study.

Table 1 Summary of sample size estimation for objective

Calculation in G*Power Software	**Parameter**	**Total sample size**
Test family: F tests Statistical test: ANOVA, Repeated Measures, between factors	**Effect size f = 0.40** **Type I error probability: 5%** **Power: 80%** **Number of groups: 2** **Number of measurements: 2** Correlation among repeated measures: 0.5	n = 40 (20 per group)
Test family: F tests Statistical test: ANOVA, Repeated Measures, within factors	**Effect size f = 0.40** **Type I error probability: 5%** **Power: 80%** **Number of groups: 1** **Number of measurements: 2** **Correlation among repeated measures: 0.5**	n = 30 (15 per group)
Test family: F tests Statistical test: ANOVA, Repeated	**Effect size f = 0.40** **Type I error probability: 5%** **Power: 80%**	n = 16 (8 per group)

Measures, within-between interaction	**Number of groups: 2** **Number of measurements: 2** Correlation among repeated measures: 0.5	

3.6 Sampling method and subject recruitment

The sampling method that was used in this study is purposive sampling. Subjects who were residing in Kelatan which were interested in the study had registered through social media advertisements. They were screened based on the inclusion and exclusion criteria of the study. Then, subjects were required to come to USM Kubang Kerian to participate in this study. The subjects were randomly allocated into either a brief mindfulness exercise group or audiobook group by block randomization and followed by a randomization sequence which was generated by an online randomizer (https://www.random.org/lists/). Subjects were given consecutive numbers and the randomization sequence was conducted without adaptation throughout the study (Refer to Appendix 5). The participants were approached with informed written consent to preserve their privacy and confidentiality and financial incentive.

3.7 Research Tool

In this study, there were six research tools used to assess the subjects which are as below (1) Functional Magnetic Resonance Imaging (fMRI), (2) Positive and Neutral Emotion Task, (3) Positive and Negative Affect Schedule – Expanded form (PANAS-X), (4) Mindfulness Attention Awareness Scale (MAAS) (refer Appendix 3), (5) Mindfulness Exercise and (6) Audiobook listening.

3.7.1 Functional Magnetic Resonance Imaging (fMRI)

In this study, a Philips Achieva 3.0T MRI (Class 2A Model number 781-277, Best, The Netherlands, Manufacture date:16April 2009) It was used for data acquisition with a standard 8/16/32 channel SENSE head coil which is located at the Radiology Department, Hospital Universiti Sains Malaysia (Seri et al., 2020). The task was administered by computer, with participants responding using a four-button answer controller. The development tool used was E – Prime version 1.0. As an experimental neuroimaging instrument, functional magnetic resonance imaging (fMRI) offered promising insight into the fundamental dynamics of brain responses and networks. Using a T2*-weighted gradient-echo EPI series brain (TE = 40 ms; TR =3000 ms; matrix =128 x 128; flip angle = 9 degrees), thirty-eight axial slices (4 mm thickness, no gap) parallel to the anterior and posterior commissures will be imaged with a temporal resolution of 3s, covering the entire brain (Hatchard et al., 2021; Malhi et al., 2005). The T1* weighted anatomical scan (TE = 8.1 s; TR = 3700 ms, FOV = 192 ×192×111 mm, matrix = 64 × 62, flip angle = 8 degree with slice thickness = 3 mm). Velcro forehead straps and foam inserts on either side will keep subjects' heads tightly immobilised in the head coil. This will help to measure the brain activity changes which is associated with the BOLD with limited movements. fMRI offers high spatial resolution which is important for research as a diagnostic tool in neuroscience.

3.7.2 Positive and Neutral Emotion Task

The positive and neutral emotion task was adapted from the Emotional Stroop task. The positive and neutral words were extracted from Affective Norms For English Words (ANEW) (Rahm et al., 2013). The block was a total of 40 neutral (Figure 2) and 40 positives (Figure 3) word stimuli chosen from ANEW by Excel

by the valence and arousal mean. For word selection, the following criteria were used Positive words had arousal ratings of more than 6.00, whereas Neutral words had arousal values of less than 5.45. Positive words had valence ratings of more than 6.00, whereas Neutral words had valence values between 4.00 and 6.00 (Roberts, 2021; Scott et al., 2009). The positive and neutral word stimuli were selected based on both criteria which include valence and arousal ratings. The emotionally valent and aroused positive and neutral terms were presented in a block design for 3 seconds per word stimuli separated by rest block for 1.5 seconds inter-stimulus period. 40 active positive and neutral word stimuli will be presented for 240 seconds and a total run time of 600 seconds for two runs. The words stimuli were projected on a black screen with a contrast white colour font the size of 160 - point Times New Roman together with a 3-point scale rating. Participants were instructed to respond by using a 3-point rating scale in the block with the aid of control button which were given on the left and right hand. They were given instruction as the right index finger respond as "Positive", right middle finger respond as "Neutral" and left index finger respond as "Negative".

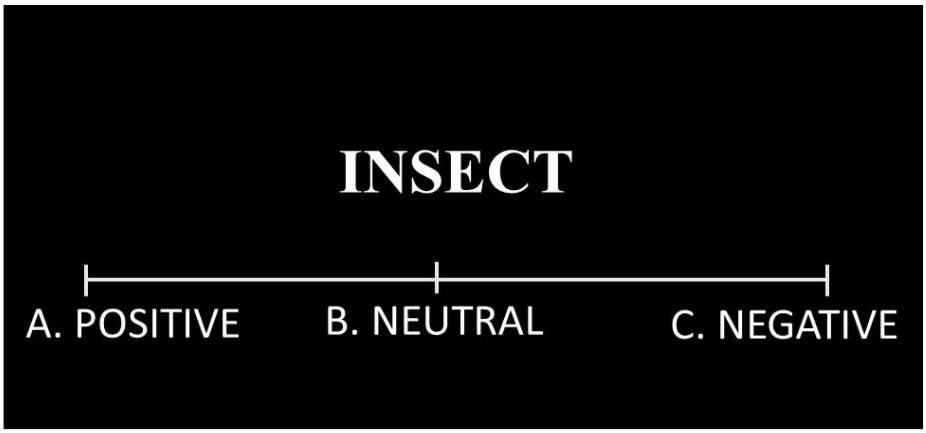

Figure 2 Neutral words stimuli